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ABSTRACT

This is a report by the National Assessment of Educational Progress that contains selected results from the Third National Assessment of Science conducted in 76-77, with emphasis on relative performance changes in achievement from 1969 to 1977. The report describes the data base and methods of measuring changes of performance. It reports on the general patterns of change in science achievement across three age groups; the trend is downwards for the 9 and the 13 year olds, but to a lesser extent than in the first and second assessments, while achievement level of the 17 year olds continues to decline over the three assessments. Students in rural areas have shown consistent improvement in succeeding assessments. The report shows that the achievement level of whites is higher than that of blacks, and that of males is also higher than that of females in all three assessments. In the three appendices at the end numerous tables of results are supplied. (GA)

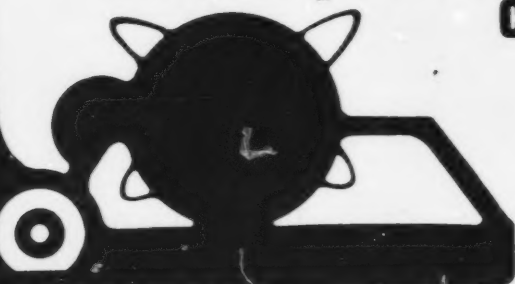
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THREE NATIONAL ASSESSMENTS OF SCIENCE: Changes In Achievement, 1969-77



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The cost figure cited above represents the total amount of money expended since late 1973 on assessments in art, career and occupational development, reading, writing, social studies/citizenship, science, basic life skills, mathematics and consumerism, resulting, to date, in numerous reports, papers, articles, presentations and assessment materials, many of which are used in state and local assessment programs. A complete list of all such materials is available upon request.

THREE NATIONAL ASSESSMENTS OF SCIENCE:

Changes in Achievement, 1969-77

SELECTED RESULTS FROM THE THIRD NATIONAL ASSESSMENT OF SCIENCE

Science Report No. 08-S-00

by the
National Assessment of Educational Progress

Education Commission of the States
Suite 700, 1860 Lincoln Street
Denver, Colorado 80295

June 1978

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FOREWORD

When the U.S. Office of Education was chartered in 1867, one charge to its commissioners was to determine the nation's progress in education. The National Assessment of Educational Progress (NAEP) was initiated a century later to address, in a systematic way, that charge.

Each year since 1969, National Assessment has gathered information about levels of educational achievement across the country and reported its findings to the nation. NAEP surveys the educational attainments of 9-year-olds, 13-year-olds, 17-year-olds and adults (ages 26-35) in 10 learning areas: art, career and occupational development, citizenship, literature, mathematics, music, reading, science, social studies and writing. Different learning areas are assessed every year, and all areas are periodically reassessed in order to measure change in educational achievement. National Assessment has interviewed and tested more than 700,000 young Americans since 1969.

Learning area assessments evolve from a consensus process. Each assessment is the product of several years of work by a great many educators, scholars and lay persons from all over the nation. Initially, these people design objectives for each subject area, proposing general goals they feel Americans should be achieving in the course of their education. After careful reviews, these objectives are given to exercise (item) writers, whose task it is to create measurement tools

appropriate to the objectives.

When the exercises have passed extensive reviews by subject-matter specialists, measurement experts and lay persons, they are administered to probability samples. The people in these samples are chosen in such a way that they represent the national population. Therefore, on the basis of the performance of about 2,500 9-year-olds on a given exercise, we can generalize about the probable achievement of all 9-year-olds in the nation. Performance is reported in terms of the percentages of young people correctly answering a given exercise or set of exercises; changes in performance are the differences between the percentages of young people correctly answering a given exercise or set of exercises from one point in time to another.

After assessment data have been collected, scored and analyzed, National Assessment publishes reports to disseminate the results as widely as possible. Not all exercises are released for publication. Because NAEP will administer some of the same exercises again in the future to determine whether the performance level of Americans has increased or decreased, it is essential that they not be released in order to preserve the integrity of the study.

See the back inside cover of this report for a complete listing of additional reports on science assessments.

ACKNOWLEDGMENTS

Assessing science achievement of young Americans throughout the nation is an undertaking of major proportions. Certainly it could not have become a reality without substantial contributions by a great number of people, not the least of whom are the students, teachers and administrators who cooperated so generously and the National Center for Education Statistics, which funds the National Assessment.

Dozens of consultants — both subject-matter specialists and lay persons — developed and reviewed these materials under the general guidance of the National Assessment of Educational Progress (NAEP) staff. Administration of exercises was handled by the Research Triangle Institute and the Measurement Research Center (MRC). Scoring was carried out by MRC and by NAEP staff members.

Special acknowledgment must go to the Analysis Advisory Committee (ANAC) of National Assessment, which developed the details of the plan for measuring change. Without their consistent support and advice, both on technical and general matters, this endeavor could not have come to pass.

Our gratitude is extended to five outstanding educators who participated in an interpretive conference on the results obtained in three science assessments: Dr. John Akey, immediate past president of the National Science Teachers Association; Dr. Mary Budd Rowe, professor of science education at the University of Florida; Dr. Paul Hurd, Professor Emeritus at Stanford University; Dr. Arthur Livermore, head, Office of Science Education, American Association for the Advancement of Science; and Dr. McKinley Nash, principal of the Evanston Township High School. The staff at NAEP appreciates the insights provided by these distinguished educators as we attempted to provide a perspective for the assessment findings.

The actual preparation of this report was a collaborative effort of the National Assessment staff. Special thanks must be given to the following people: Data Processing Department for data processing support; Fred Daniels for technical support; Marci Reser, Eileen Wollam and Paula Pitchford for production; and David Wright for technical planning, analysis and editing. The report was written by Barbara Holmes.

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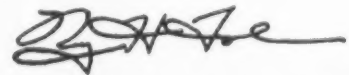
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Lincoln E. Moses, professor of statistics, dean of the graduate school, Stanford University (1974—77).

Ralph W. Tyler, Science Research Associates, Chicago, Illinois (1965—69).



Roy H. Forbes
Director

HIGHLIGHTS OF RESULTS

- The downward trend in science achievement observed from the first to the second assessment appears to be lessening for 9- and 13-year-olds in the third assessment. For these two age populations, it appears that a continued decline in achievement in physical science is accompanied by some stability in achievement in biology.
- The achievement level of 17-year-olds continues to decline. Seventeen-year-olds declined in performance from the first to the second assessment and from the second to the third assessment.
- Students in extreme-rural communities, at each age level, have improved in science achievement during the eight years spanned by the three assessments of science.
- A gap continues to exist in the achievement levels of whites and blacks: the achievement level of whites was higher than that of blacks in each assessment. However, black 13-year-olds improved in achievement on physical science exercises from the second to the third assessment.
- The achievement level of males at each age was higher than that of females in all three assessments of science.

CHAPTER 1

INTRODUCTION

Achievement of American youth in science has been assessed on three occasions by the National Assessment of Educational Progress (NAEP). The first assessment was conducted in 1969-70, the second in 1972-73 and the third in 1976-77. These assessments were designed to establish how defined groups of American students respond to science exercises, rather than the performance level of individual students.

In each assessment, students were administered a variety of questions designed to assess achievement across three broad objectives of science education: (1) that American students should know the fundamental aspects of science; (2) that they should understand and apply the fundamental aspects of science in a wide range of problem situations; and (3) that they should appreciate the knowledge and processes of science, the consequences and limitations of science, and the personal and social relevance of science and technology in our society.

The second and third assessments have included exercises from the first science assessment so that a base could be established for determining changes in student achievement over time. The retention of some exercises is essential, but also limiting in that results from exercises common to all assessments tend to reflect the concerns of science education in the late sixties and early seventies more than contemporary concerns in science education. For instance, today's science objectives stress the importance of scientific literacy to the culture, the social and moral aspects of scientific decision making in areas such as ecological preservation and energy availability and usage. Also, the exer-

cises common to all three science assessments are more often than not aimed at the knowledge component of the cognitive domain.

To overcome these limitations, National Assessment infuses each assessment with new exercises so that the current trends and emphases in science education can be more accurately reflected and so that the higher taxonomic levels of the cognitive domain are probed.

In addition, many science educators consider attitudes and values to be among their most important education objectives. Therefore, the third assessment of science achievement included nine sets of affective and experiential exercises so that attitudes and values held by students could be described. Data collected on affective and experiential exercises will be the subject of forthcoming reports.¹ These exercises will not be the subject of this report because the present focus is on changes in achievement over time.

Description of Data Base

The percentages presented in this report are based on data collected from representative national samples of three age populations enrolled in school at three points in time. The age populations were assessed at the following times:

¹ *The Third Assessment of Science, 1976-77: Released Exercise Set* (Denver, Colo.: National Assessment of Educational Progress, 1978). Two future reports are planned: one on the affective and experiential exercises, and one on the baseline data collected in the third assessment of science.

9-year-olds	Jan.—Feb. 1970, 1973 and 1977
13-year-olds	Oct.—Dec. 1969, 1972 and 1976
17-year-olds	March—May 1969, 1973 and 1977

In each assessment, packages of exercises were administered to samples of about 2,500 students. A total of 7 to 13 different packages were administered to each age population. No student responded to all exercises. The packages, which require approximately 45 minutes to complete, were administered by a trained professional field staff using paced, audio tapes to assure uniform assessment conditions and to minimize the effect of variation in reading skills on performance. In the first assessment, packages contained a mix of science, citizenship and writing exercises; in the second assessment, packages contained science and mathematics exercises; and, in the third assessment, packages contained science exercises only.

Measuring Change in Performance

Changes in the performance of an entire age population — all 9-year-olds, all 13-year-olds or all 17-year-olds — are indicated by changes in the percentage of young people

Which one of the following is MOST likely to make a rock break open?

- ☐ Dew evaporating on the rock
- ☐ Tree leaves decaying on the rock
- ☐ Snow melting in a crack in the rock
- ☒ Water freezing in a crack in the rock
- ☐ I don't know.

Percent of Correct Responses*

1973	1977
51.9	49.4

Which of the following would be most likely to rust?

- ☒ An iron nail
- ☐ A plastic comb
- ☐ A glass marble
- ☐ A rubber balloon
- ☐ I don't know.

Percent of Correct Responses*

1973	1977
90.6	91.6

correctly answering an exercise, or a group of exercises, about science. Changes in the performance of certain groups of students — for example, males, females, Southerners and so on² — are indicated by changes in the percentage of success for a group and by changes in the group's position compared to the national percentage of success. By observing these two changes we can determine, first, whether a larger or smaller proportion of respondents answered an exercise correctly in one assessment than in another; and second, whether or not there was a change between assessments in the group's standing compared to the nation as a whole. Both types of information contribute to an understanding of whether the achievement level of a given group has changed.

The estimated average percentage of success is calculated by summing the percentage of correct responses on each exercise and dividing the total by the number of exercises. For example, the following three physical science exercises were administered to 9-year-olds in 1973 and in 1977.

²See Chapter 3 for definitions of groups for which National Assessment reports findings.

Which of the following is the largest body?

- ☐ Earth
- ☐ Mars
- ☐ The Moon
- ☒ The Sun
- ☐ Venus
- ☐ I don't know.

Percent of Correct Responses*

1973	1977
58.0	56.2

*Standard errors appear in Appendix C.

In 1973, the percentages of students answering each exercise correctly were 51.9, 90.6 and 58.0, respectively. These percentages total 200.5. The average percentage of success (200.5 divided by three exercises) is 66.9 for 9-year-olds on these exercises. Similarly, we can determine that in 1977 the average percentage of success on these same exercises was 65.7. By subtracting the average percentage for 1973 from that of 1977, we can estimate that a change of -1.2 occurred nationally among 9-year-olds.

To determine a group's position relative to the nation, we can compare its percentage of success to the national percentage of success achieved in each assessment. For example, the percentage of students in the rural group responding correctly to the first exercise displayed was 46.6 in 1973. In 1977, 51.5% of the students in the rural group responded correctly to the same exercise. Rural students were 5.3

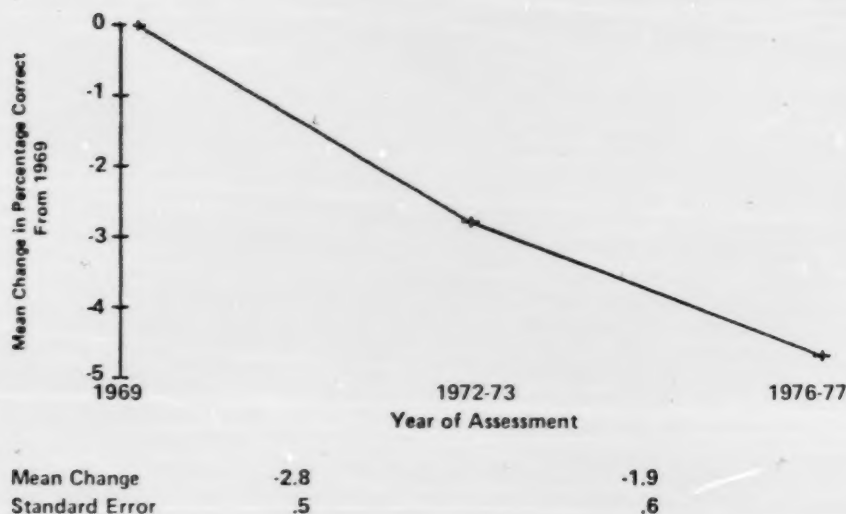
percentage points below the national level (51.9%) on this exercise in 1973, but were above the national level (49.4%) in 1977. These students improved on this exercise (4.9%) while the nation as a whole declined in achievement on the exercise (-2.5%). So, relative to the nation, the rural group experienced a large positive change (7.4%).

Throughout this report, changes in achievement are based on identical sets of exercises administered to an age population in at least two assessments. National Assessment computes the percentage of respondents answering each exercise correctly and then averages those percentages to estimate mean performance. Estimated changes in mean performance are based on the performance of 17,000 to 29,000 respondents on 70 to 92 exercises at two different times. For example, in 1973, about 26,000 17-year-olds responded to 70 exercises that were also administered to 29,000 17-year-olds in 1977.³ We estimated the average performance of 17-year-olds on

those exercises to be 48.4% in 1973 and 46.5% in 1977. By subtracting 48.4 from 46.5 we estimate that 1.9% fewer 17-year-olds could correctly answer the 70 science exercises in 1977 than in 1973. Between 1969 and 1973, 2.8% fewer 17-year-olds correctly responded to the 64 exercises common to both of those assessments. Combining both sets of information, National Assessment estimated that for 17-year-olds enrolled in school, performance declined about 3 percentage points from 1969 to 1973 and another 2 percentage points from 1973 to 1977. A graph of these results for 17-year-olds follows. Similar graphs for all ages appear in Chapter 2. The numerical values for mean change and standard errors of change are presented with each graph.

³Details on numbers of exercises and sample sizes are given in Appendixes A and B.

Changes in Science Achievement for 17-Year-Olds From 1969 to 1973 and From 1973 to 1977



When change statistics are discussed in this report, only those greater than two standard errors are mentioned. The standard error is a measure of the variability of a statistic due to sampling and other random fluctuations. In reporting changes greater than two standard errors, we are confident that changes this large would occur by chance in fewer than 5% of all possible replications of our sampling and data collection procedures.

When summarizing more general trends

across age populations, reporting groups or assessments, we are less restrictive. For example, all age populations across all adjacent assessments showed a decline on the physical science exercises, but not all declines were statistically significant. However, the consistency of those results seems noteworthy, even if individual changes are not significant. More details on estimating changes in achievement are given in Appendix A, which also contains tables of mean percentages and their standard errors.

CHAPTER 2

GENERAL PATTERNS OF CHANGE IN SCIENCE ACHIEVEMENT ACROSS THREE AGE POPULATIONS

Exhibit 1 displays the general patterns of science achievement for the three age populations. This exhibit shows the assessment year for each age population and the mean change in percentages of correct responses between assessment years.

Nationally, both 9-year-olds and 13-year-olds declined in achievement from the first to the second assessment of science. Students who were 9 and 13 in 1972-73 performed less well than did those students who were 9 and 13 in 1969-70. This pattern was not repeated, however, from the second to the third assessment. Neither 9- nor 13-year-olds declined significantly in achievement from 1972-73 to 1976-77.

The national results for students at age 17 show a somewhat different pattern. A comparison of achievement levels between those students who were 17 in 1969 and those at age 17 in 1973 shows a substantial decline in overall performance. There was further decline in performance for this age population between the second and third assessment.

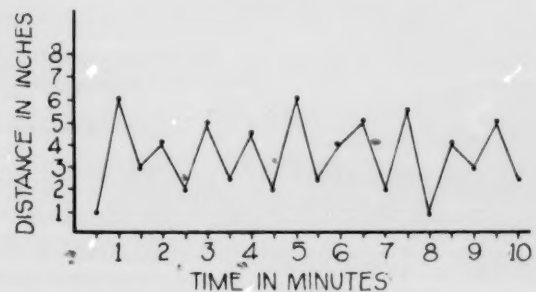
Exhibits 2 and 3 display the achievement levels of all age populations on the biology and physical science exercises, respectively.

9-Year-Olds

Nine-year-olds declined in achievement on physical science exercises from 1970 to 1973

and continued to decline between 1973 and 1977. In the biological sciences, however, 9-year-olds declined slightly from 1970 to 1973 and improved slightly from 1973 to 1977. The exercises displayed below illustrate the trend in biology.

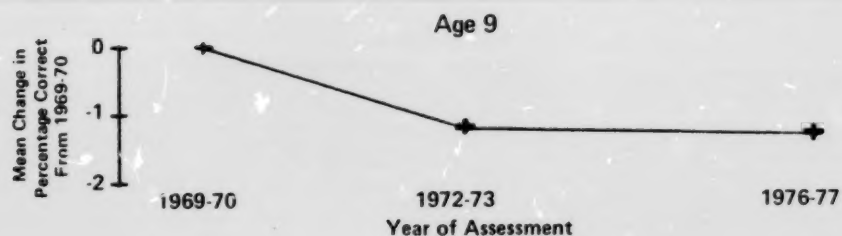
Each dot in the graph below shows the measurements made by a scientist while he watched a beetle's movements for ten minutes. Select the sentence that BEST tells what the graph shows



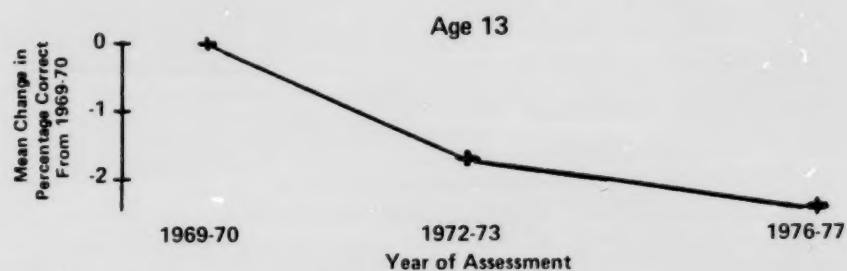
- ☐ The graph shows that the beetle was looking for food.
- ☒ The graph shows that the beetle's movements were not steady.
- ☐ The graph shows that the beetle was trying to climb the wall.
- ☐ The graph shows that the beetle changed direction every half minute.
- ☐ I don't know.

The percentage of 9-year-olds responding correctly to this exercise in 1973 was 35.2; in 1977, it was 38.0.

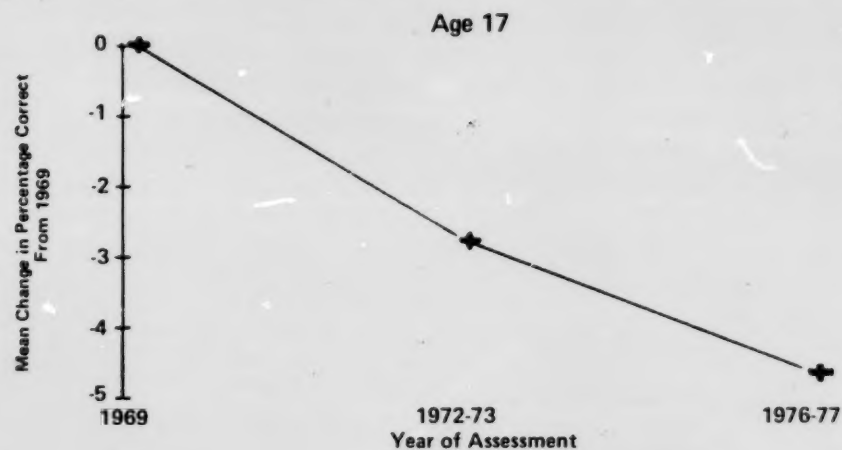
EXHIBIT 1. Changes in Science Achievement From 1969-70 to 1972-73
and From 1972-73 to 1976-77 for 9-, 13- and 17-Year-Olds



Mean Change	-1.2	-1.1
Standard Error	.6	.6



Mean Change	-1.7	-2.7
Standard Error	.6	.6



Mean Change	-2.8	-4.7
Standard Error	.5	.6

EXHIBIT 2. Changes in Biology Achievement From 1969-70 to 1972-73
and From 1972-73 to 1976-77 for 9-, 13- and 17-Year-Olds

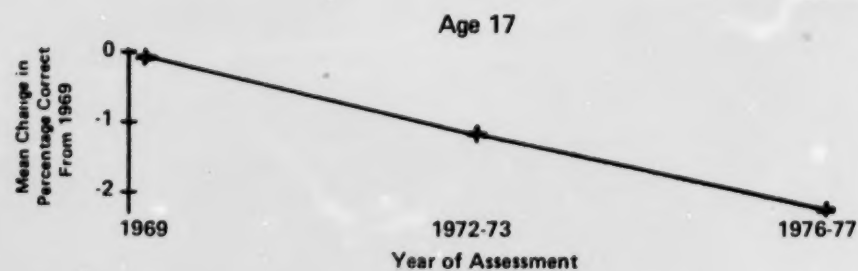
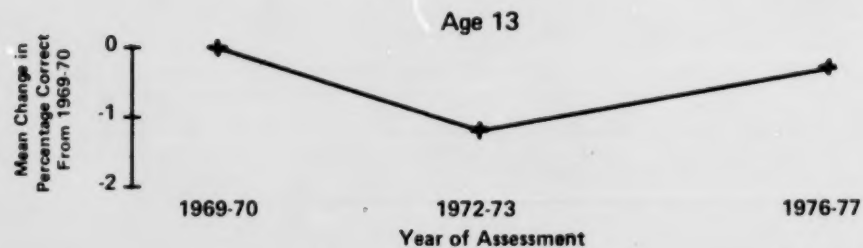
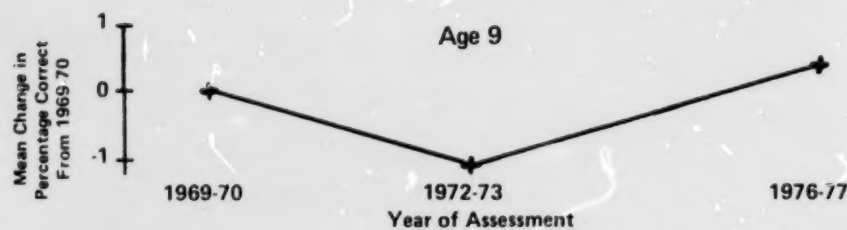
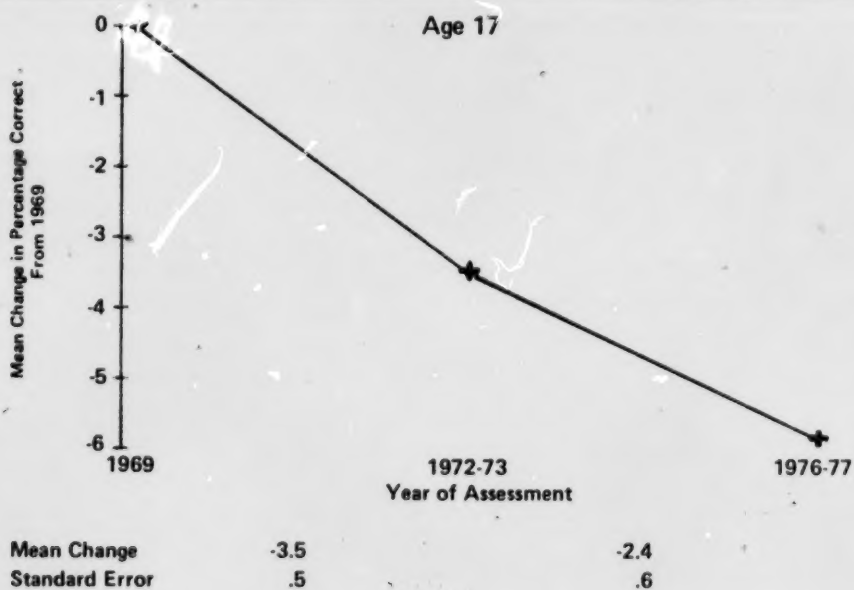
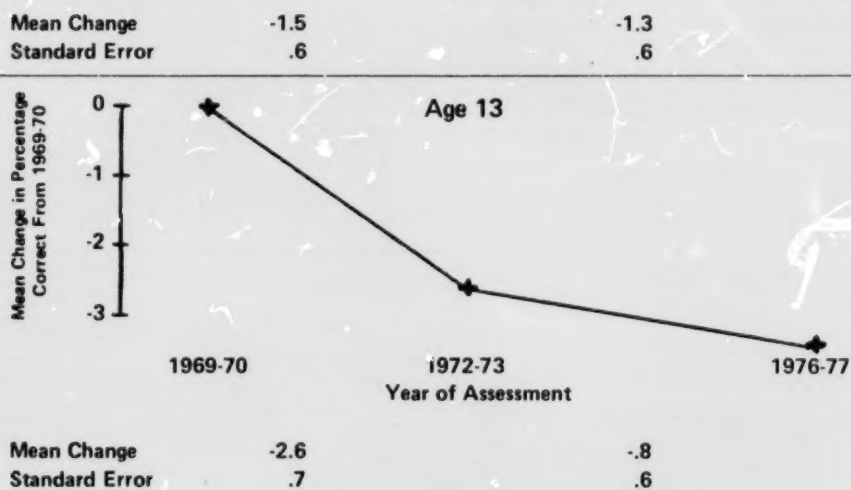
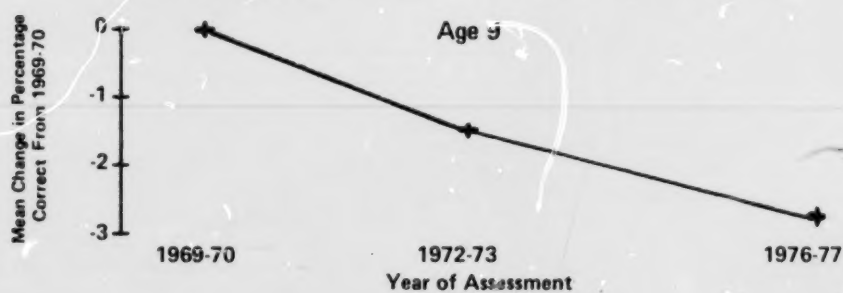


EXHIBIT 3. Changes in Physical Science Achievement From 1969-70 to 1972-73 and From 1972-73 to 1976-77 for 9-, 13- and 17-Year-Olds



This caterpillar will grow up to look like which of the following?



will grow up



- ☐ A
☐ B
☐ C
☐ D
☐ I don't know.

In 1970, the percentage of youngsters choosing the correct response to this exercise was 91.3; in 1973, it was 85.2, which indicated a decline in performance on the exercise. In 1977, however, the percentage of youngsters choosing the correct response rose to 90.7.

The increases on these two sample exercises are consistent with the trend on the total group of biology exercises administered to 9-year-olds.

13-Year-Olds

Thirteen-year-olds did not decline in achievement on biology exercises over the period of three science assessments. They did, however, decline from 1969 to 1976 in physical science, although the rate of decline slowed between 1972 and 1976. This trend is illustrated by the following exercises.

Some air is pumped out of a can and the can collapses. Which of the following best explains why this happened?

- ☐ Air molecules inside the can collapsed.
☐ Pumping out the air molecules weakened the can.
☐ The air molecules inside the can condensed to form water.
☒ The air pressure inside the can became less than the pressure outside the can.
☐ Pumping the air out of the can increased the number of air molecules around the can.
☐ I don't know.

Percent of Correct Responses*

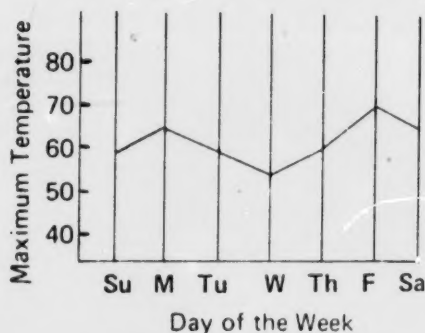
1970	1973	1977
72.2	63.9	63.0

The statement that the relative humidity is 50 percent means that

- ☐ The chance of rain is 50 percent.
☐ The atmosphere contains 50 pounds of water per cubic mile.
☐ The atmosphere would be saturated with water if the air temperature were 50° F.
☒ The atmosphere contains half as much water as it could contain at its present temperature.
☐ I don't know.

Percent of Correct Responses*

1970	1973	1977
28.4	24.8	27.0



According to the graph above, the highest temperature was recorded on

*Standard errors appear in Appendix C.

- ☐ Sunday.
- ☐ Monday.
- ☐ Wednesday.
- ☒ Friday.
- ☐ Saturday.
- ☐ I don't know.

Percent of Correct Responses*

1970	1973	1977
92.5	90.5	90.2

*Standard errors appear in Appendix C.

The average percentage of success on these three exercises was 64.4 in the first assessment, 59.7 in the second assessment and 60.1 in the third assessment. Thus, a fairly sharp decline is apparent between the first and second assessment, but the achievement level of 13-year-olds in the third assessment was a bit above that of 13-year-olds in the second assessment. The pattern illustrated by these three exercises is similar to the performance of 13-year-olds on the larger set of physical science exercises.

17-Year-Olds

The performance of 17-year-olds on biology and physical science exercises declined from the first to the third assessment, but the decline was greater in the physical sciences. The changes in results for the following exercises are typical of the changes in physical science knowledge over the three assessments.

Which of the following happens when any combustion reaction takes place?

- ☒ Heat is evolved.
- ☐ Some oxygen is formed.
- ☐ No chemical change occurs.
- ☐ All of the products are gases.
- ☐ Ions are major products formed.
- ☐ I don't know.

Percent of Correct Responses*

1969	1973	1977
67.5	63.3	54.4

Suppose that a rubber balloon filled with air does not leak and that it is taken from Earth to the Moon. One can be sure that on the Moon, the balloon will have the same

- ☐ Size as on Earth.
- ☒ Mass as on Earth.
- ☐ Weight as on Earth.
- ☐ Rate of fall as on Earth.
- ☐ Ability to float as on Earth.
- ☐ I don't know.

Percent of Correct Responses*

1969	1973	1977
35.6	26.8	29.1

If a mineral sample contains large crystals, geologists believe that the mineral probably

- ☐ Was formed in a volcano.
- ☐ Contains a valuable metal.
- ☐ Cooled instantly under water.
- ☐ Has cleavage in three directions.
- ☒ Solidified slowly from hot liquid.
- ☐ I don't know.

Percent of Correct Responses*

1969	1973	1977
28.7	23.6	25.1

The statement that the relative humidity is 50 percent means that

- ☐ The chance of rain is 50 percent.
- ☐ The atmosphere contains 50 pounds of water per cubic mile.
- ☐ The atmosphere contains 50 grams of water per cubic meter.
- ☐ The atmosphere would be saturated with water if the air temperature were 50° F.
- ☒ The atmosphere contains half as much water as it could contain at its present temperature.
- ☐ I don't know.

Percent of Correct Responses*

1969	1973	1977
47.2	49.0	42.2

*Standard errors appear in Appendix C.

The average percentage of success on these four exercises was 44.7 in the first assessment, 40.7 in the second assessment and 37.7 in the

third assessment. The overall pattern of decline on all physical science exercises is mirrored in this smaller collection of exercises.

Over the period of three science assessments, a smaller proportion of students at each age responded correctly to science exercises administered in two or more assessments. However, the results of the third assessment indicate that the decline in science performance is slowing among students at

ages 9 and 13. For these two ages, it appears that a continued decline in performance on physical science exercises has been accompanied by more stable levels of achievement in biology. The decline in achievement noted among 17-year-olds from the first to the second assessment continued to the third assessment. Seventeen-year-olds continued to decline in biology from the second to the third assessment, but their decline in achievement on physical science exercises was greater.

CHAPTER 3

PATTERNS OF SCIENCE ACHIEVEMENT FOR SELECTED REPORTING GROUPS

National Assessment, unlike most testing programs, does not report scores for individuals.¹ Rather, NAEP reports how defined *groups* of students respond to certain exercises. Students are classified by age, sex, race, region of the country, level of parents' education, community size and community type. Definitions of these groups are presented below.

Reporting Groups Defined

Age

Results are presented for 9-, 13- and 17-year-olds enrolled in school at the time of the assessment.

Sex

Results are presented for males and females.

Race

Results are presented for blacks and whites.

¹More detailed information on the methodology employed by National Assessment can be found in the *General Information Yearbook, Report 03/04-GIY, 1971-72 and 1972-73 Assessments* (Denver, Colo.: National Assessment of Educational Progress, 1974). Specific chapters on sampling, objectives and exercise development, administration, data processing and analysis procedures can be found in this volume.

Region

The country has been divided into four regions — Northeast, Southeast, Central and West. States included in each region are shown on the following map.



Size of Community.

Big city. Students in this group attend schools within the city limits of cities with a population over 200,000.

Fringes around big cities. Students in this group attend schools within metropolitan areas served by cities with a population greater than 200,000 but outside the city limits.

Medium city. Students in this group attend schools in cities having a population between 25,000 and 200,000 not classified in the fringes-around-big-cities category.

Smaller places. Students in this group attend schools in communities having a popu-

lation less than 25,000 not classified in the fringes-around-big-cities category.

Type of Community

These communities are defined by an occupational profile of the area served by a school as well as the size of the community in which the school is located.

Advantaged-urban communities (high metropolitan). Students in this group attend schools in or around cities with a population greater than 200,000 where a high proportion of the residents are in professional or managerial positions.

Disadvantaged-urban communities (low metropolitan). Students in this group attend schools in or around cities with a population greater than 200,000 where a high proportion of the residents are on welfare or are not regularly employed.

Extreme rural. Students in this group attend schools in communities with a population under 10,000 where most of the residents are farmers or farm workers.

Level of Parental Education

Students' reported levels of parental education; these were then classified by National Assessment into three categories: (1) those whose parents did not graduate from high school, (2) those who have at least one parent who graduated from high school but did not continue beyond high school and (3) those who have at least one parent who has had some post high school education.

The performance of most of the reporting groups compared to the nation was highly consistent across the three science assessments. That is, whatever the level of group performance in 1969-70 — either higher or

lower than the nation — the group declined in achievement in successive assessments at about the same rate as the nation.

Certain groups across all three age populations have tended to perform above the national level in each assessment of science achievement. These are:

- Students in the Northeastern region.
- Nine- and 13-year-olds in the Central region.
- Male students.
- White students.
- Students who have at least one parent with post high school education.
- Students in advantaged-urban communities.
- Students in suburbs of big cities.

Conversely, certain groups across all age levels have tended to perform below the national level in each assessment of science achievement. These are:

- Students in the Southeastern region.
- Female students.
- Black students.
- Students whose parents have not graduated from high school.
- Students in disadvantaged-urban communities.
- Students in big cities.

Some groups across all age levels have tended to show little, if any, deviation from the national level of achievement. These are:

- Seventeen-year-old students in the Central region.

- Students in the Western region.
- Students in medium-sized cities.
- Students in smaller places.

The achievement levels of certain groups appear to have changed over the course of three science assessments. In 1969-70, each age population in rural communities performed below the nation. However, each age population in rural communities showed consistent improvement in succeeding assessments. By 1976-77, the achievement level of all three age populations in rural communities was at or near the national level. This improvement may be due, in part, to the changing characteristics of rural schools.

Rural school districts have continued to consolidate each year, resulting in the fact that the populations attending them have

become more heterogeneous. Also, urban areas have continued to lose population to smaller towns and rural areas throughout the seventies.² Thus, the change in performance for students in extreme-rural schools may be due to an improvement in instruction or management in those schools, or due to a change in the composition of student population attending them. More likely, however, the improvement is due to a combination of reasons.

² U.S. Bureau of the Census, "Mobility of the Population of the United States: March 1970 to March 1973," *Current Population Reports, Series P-20, No. 262* (Washington, D.C.: U.S. Government Printing Office, 1974); U.S. Bureau of the Census, "Geographic Mobility: March 1975 to March 1977," *Current Population Reports, Series P-20, No. 320* (Washington, D.C.: U.S. Government Printing Office, 1974); National Center for Education Statistics, *The Condition of Education, 1977* (Washington, D.C.: U.S. Government Printing Office, 1977).

CHAPTER 4

PUTTING THE RESULTS INTO PERSPECTIVE

To provide a context for the findings contained in this report, National Assessment invited five outstanding educators to speculate about their implications and to examine them in light of current trends in science education. They are: Dr. John Akey, immediate past president of the National Science Teachers Association; Dr. Mary Budd Rowe, professor of science education at the University of Florida; Dr. Paul DeHart Hurd, professor emeritus at Stanford University; Dr. Arthur Livermore, head, Office of Science Education, American Association for the Advancement of Science; and Dr. McKinley Nash, principal of the Evanston Township High School, Evanston, Illinois. These educators joined NAEP staff members in discussion of the results from three science assessments.

Following are some of their general observations and specific comments. It should be noted that consultants' comments are their observations as individuals and do not represent the positions of any organizations with which they are affiliated.

Much of the group's speculation about what may have influenced science achievement over the last decade centered around changes in media attention devoted to science, changes in the resources devoted to science education and changes in the science curriculum.

It is possible, they argued, that high achievement levels attained in the 1969 assessment of science reflected the high level of public consciousness of science during the early days of space exploration and the

impact of new science curricula developed by scientists and teachers on a nationwide basis.

Both formal and informal learning experiences were enriched during the sixties as great sums of money were put into teacher preparation, curriculum development and implementation, while the media contributed to an explosion of information about scientific problems related to space research. Public awareness and interest reached an apex at the time of the first moon landing, which occurred at about the time of the first assessment of science, and interest began to decline shortly afterward. McKinley Nash pointed out: "We need an assessment of where we stand in curriculum development since the Sputnik era. Although many of the teachers trained during that period are still carrying on the emphases in science that grew out of that era, funding levels have not kept pace with the rising costs of materials and facilities." Arthur Livermore, too, noted that funding for much needed inservice training programs began to decline as public and political attention turned elsewhere.

Changes in the relative strength and content of the science curriculum may well have influenced the results National Assessment has described, the group felt. John Akey noted that an overemphasis on the "basics" in the elementary classroom has diminished the amount of time available for the study of science: "To me, it is very positive that the decline in science achievement is not greater when we consider that over the last four years, science has practically been ignored in elementary schools because of all the attention given to reading

and mathematics." Paul Hurd concurred, expressing hope that parents would realize that science is as basic as anything else, particularly in a society as technologically oriented as ours.

Opportunities for exposure to science also seem to be diminishing in high schools. Several of the consultants suggested that the continued decline in achievement levels of 17-year-olds over the period of three science assessments may be due, in part, to the fact that science courses are often elective after the 10th grade. The consequence is that many 17-year-olds do not continue the pursuit of science education after their sophomore years. As Arthur Livermore put it: "I would suggest that for 17-year-olds, the steep decline in physical science achievement is related to decreasing enrollments of high school students in physics and chemistry. In fact, less than half the high schools in the country even have physics courses in the curriculum."

Because the NAEP assessments required considerable knowledge of the physical sciences, several members of the group felt that changes in the structure of the science curriculum could explain why 17-year-olds are declining at a faster rate than the younger students. The younger students might be expected to slow their rate of decline because elementary and junior high school science programs expose students to about equal amounts of biological and physical sciences. On the other hand, 17-year-olds, who typically are not electing courses in physics and chemistry, could be expected to continue their decline in the physical sciences, but not in the biological sciences where most students have had at least one course in high school.

Another change in the curriculum may also be related to the National Assessment results. Several of the educators stressed the fact that today's curriculum — which stresses science concepts, problem solving, decision making, and so on — is quite different from the fact-oriented curriculum that is still largely reflected in the NAEP science exercises. They pointed out that values and attitudes are

considered more important than they used to be. NAEP assessed values and attitudes in the third assessment, but the results do not appear in this change information, which is based on cognitive items only. Thus, the contemporary science education curriculum and the change items used in the three assessments have grown apart. Of necessity, items were retained from the first assessment for inclusion in the second and third assessments; yet these items may be assessing areas that currently receive less emphasis in the classroom today.

In reference to regional achievement results, Dr. Rowe pointed out that student achievement in the Southeastern region of the country has been consistently lower than that of students in the other three regions. She commented: "Even though students in the Southeast did not decline disproportionately to the nation, the achievement level of students in the Southeast is very low when compared to the national achievement level. Because a technical society relies on a scientific base, all regions within that society require scientifically literate populations."

On the achievement level of minority students and females, the consultants provided several insights of general interest. Dr. Nash cautioned: "Gross comparisons of racial groups tend to result in a distorted picture of achievement; it would be helpful if these data were analyzed in terms of other factors as well. For example, when factors such as social class are not controlled in research, results of achievement by racial groups tend to be misleading because of the disproportionate number of blacks in the echelons of the lower-economic class." Nevertheless, he and the others agreed that the achievement level of blacks at ages 9, 13 and 17 is low nationally. The same tends to be the case for females as well as for those students who report having neither parent graduated from high school and for those students in schools in disadvantaged-urban communities. Paul Hurd commented: "It would appear that some of the social engineering of the past decade has not

resulted in significant gains in achievement in science."

Discussion of efforts that might be taken to improve the situation turned to compensatory education programs. Dr. Nash pointed out that "one must realize that compensatory intervention can be of some value for secondary students. However, compensatory education programs in the cognitive areas should be primarily directed to younger students in the early grades because by the time a student is at the secondary level, the effects of a cumulative deficit are more difficult to overcome. Conversely, when intervention occurs in the early grades and is maintained, benefits are becoming evident by age 13." The consultants expressed the hope that greater efforts would be made to involve minorities and females in science because all of our available human resources are not being used.

Generally, the group felt that the future in science education is likely to be different in rationale, purpose and focus from past years. They suggested that:

- Inservice teacher education and

preservice education in science should be coordinated.

- Teacher education should focus more on the rationale for the teaching of science in a personal and social context. Teachers should know more about the social and economic dimensions of modern science and science policy.
- Teacher education should include a background in the interaction of science, technology and values and how these relate to resolving science-based social problems.

The group of educators looked forward to future assessments of science achievement because the exercises would reflect the shift in emphases and goals of science education. They suggested that the exercises from the third assessment of science are broader in scope and more relevant to contemporary trends in science education than the change exercises used as a basis for this report. Results of the third assessment will be released soon.

APPENDIX A

MEASURING CHANGE IN THREE SCIENCE ASSESSMENTS

National Assessment has measured science knowledge and skills of 9-, 13- and 17-year-olds in 1969-70, 1972-73 and 1976-77. This appendix describes how NAEP measured changes in percentages of correct responses over the three assessments. In addition, mean percentages of correct responses for the nation are given in Table A-1, while percentages of correct responses for reporting groups compared to the nation are given in Tables A-2 to A-7. The results are presented for the total change exercise sets (all change exercises for 1969-70 to 1972-73 and all change exercises for 1972-73 to 1976-77) and the exercise subsets common to all three assessments. In the following paragraphs, change measures are described for 17-year-olds. The same procedure was followed for 9- and 13-year-olds, and results are presented for all three age populations.

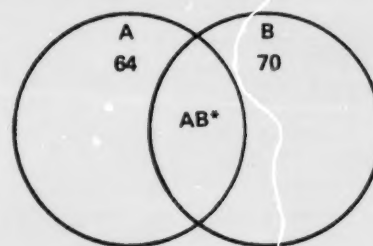
In 1969 and again in 1973, several packages of exercises (items) were administered to nationally representative samples of 17-year-olds enrolled in school. Each sample of about 2,500 students was given only one package of exercises. Among the many exercises administered in the two assessments were 64 science exercises that we used to measure changes in performance between the two assessments. After the 1973 assessment, 41 of those exercises were released in published reports and not reused for measuring change.¹ They

¹Exercises are released and replaced for many reasons. Releasing exercises allows public evaluation of the appropriateness of our items and makes them available to other users. It also makes room for new exercises that can improve the coverage of the domain of science and reflect changes in what scientists, educators and other concerned citizens consider to be important for students to know and be able to do.

were replaced by 47 new exercises that were administered for the first time in 1973. Those 47 exercises, plus 23 exercises from both the 1969 and 1973 assessments, were administered again in 1977 to national probability samples of 17-year-olds enrolled in school (see Table A-1).

The following diagram illustrates the three sets of exercises.

Exercises Administered to 17-Year-Olds



Exercises administered
in 1969 and 1973

Exercises administered
in 1973 and 1977

*The common AB subset consists of 23 exercises; thus, set A-AB = 41 exercises and set B-AB = 47 exercises.

The 23 exercises administered in all three assessments of 17-year-olds provide a consistent, but limited, change measure. They are representative of the exercises used to measure change between the first two assessments but may not be representative of all of the new exercises added to measure change between the second and third assessments. If changes in performance and relative performance had been different on the 23 old exercises and 47 new exercises, then we would have reported change separately for the two sets.

Table A-1 reveals that, in some instances, the average percentage correct is quite different for the two- and three-assessment subsets, but *changes* in average percent correct are quite similar (this is even more apparent in changes in relative performance, discussed below). The similarity among change measures is shown graphically in Exhibit A-1 where the change from 1969-70 to 1972-73 and from 1972-73 to 1976-77 has been plotted for each of the exercise sets discussed above.

Exhibit A-1 shows similar change trends for all exercise sets. It is interesting to note that there is a greater divergence between the sets in the later change (from 1972-73 to 1976-77) than on the earlier change (from 1969-70 to 1972-73), and that the declines for new exercises were consistently less than the declines for old exercises. However, since all these changes were within two standard errors of each other, and since the combined sets of exercises were larger and more representative of the science curricula in all three assessments, results for those exercise sets are emphasized in the body of this report.

Change Results for Reporting Groups

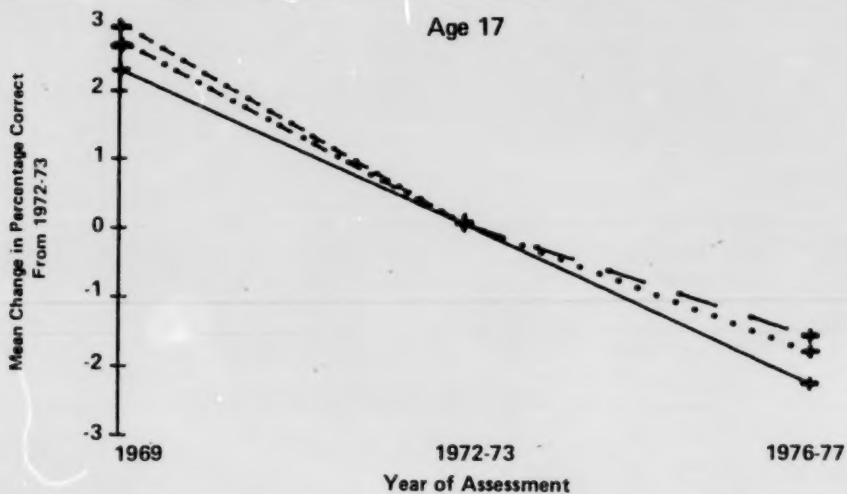
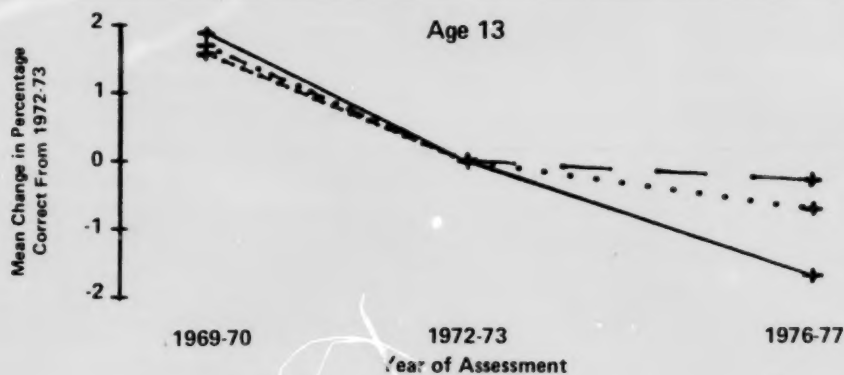
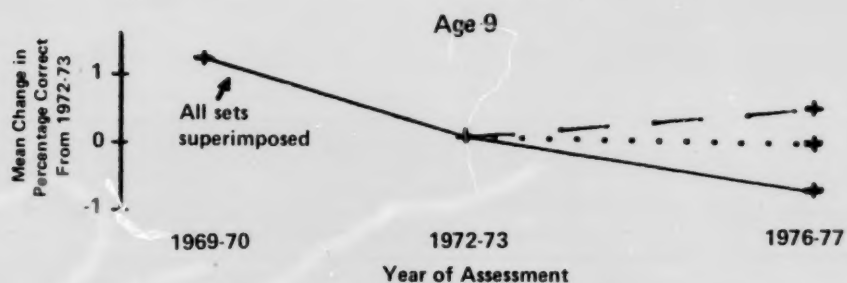
Change results for sex, race, region, parental-education, type-of-community and community-size reporting groups are presented in this report. Group results are computed by estimating the mean percentage correct for a reporting group in the same manner as described above for the national mean percentage correct. The national mean is then subtracted from the group mean to obtain the group's difference from the national percentage correct. For example, the mean percentage of correct responses for Northeastern 17-year-olds in 1977 was 48.8, while the

mean percentage for all 17-year-olds in 1977 was 46.5. Subtracting the national mean from the Northeastern mean yields a Northeastern 17-year-old relative performance advantage of 2.3 percentage points.

Differences in group percentage (relative performance) and changes in those differences from 1969-70 to 1972-73 and from 1972-73 to 1976-77 for the full exercise sets (A and B) are contained in Tables A-2 through A-4 and discussed in Chapter 3. Tables A-5 through A-7 contain relative group performance results for the exercise subsets (AB) common to all three science assessments. Comparisons of Tables A-2 through A-4 with Tables A-5 through A-7 show that while the relative performance of a reporting group may vary slightly from one exercise set to another, the *changes* in relative performance are highly consistent.

In this report, we have chosen to emphasize changes in relative performance for several reasons. Most reporting groups changed very little in relative position over the course of the three assessments. That is, whatever the initial advantage or disadvantage of a reporting group, the average percentage of correct responses changed at about the same rate as the nation for each age population. The mean difference from the nation, since it removes the overall national trend, makes it easier to detect those reporting groups, such as extreme rural, that have undergone major shifts in position relative to the nation. Those differences were highly stable over the three assessments: only 6 of 108 possible changes were consistent enough to discuss in Chapter 3. By emphasizing changes in relative performance, trends across age groups, such as the increase in sex differences with age, are also more readily detected.

EXHIBIT A-1. Changes in Mean Percentage Correct From 1969-70 to 1972-73 and From 1972-73 to 1976-77 on Exercises Used in Two Assessments, Three Assessments and Combined Exercises for 9-, 13- and 17-Year-Olds



- Exercises used in 1969-70, 1972-73 and 1976-77 (Set AB).
- - - - Exercises used in 1969-70 and 1972-73 only (Set A-AB).
- • - • - • Total exercise Set A for 1969-70 and 1972-73.
- Exercises used in 1972-73 and 1976-77 only (Set B-AB).
- • • • • Total exercise Set B for 1972-73 and 1976-77.

TABLE A-1. Mean Percentage Correct, Changes in Mean Percentages Correct and Standard Errors From 1969-70 to 1972-73 and From 1972-73 to 1976-77 on Exercises Used in Two Assessments, Three Assessments and Combined Exercise Sets for Ages 9, 13 and 17

	Exercise Set	1969-70 to 1972-73			Change 1969-70 to 1972-73	Exercise Set	1972-73 to 1976-77			Change 1972-73 to 1976-77
		Number of Exercises	1969-70	1972-73			Number of Exercises	1972-73	1976-77	
Age 9	1970, 1973 & 1977 (AB) S.E.	30	64.8 (.4)	63.7 (.4)	-1.2§ (.6)	1970, 1973 & 1977 (AB) S.E.	30	63.7 (.4)	62.9 (.5)	-.8 (.6)
	1970 & 1973 (A-AB)*	62	59.1	57.9	-1.2	1973 & 1977 (B-AB)	41	44.0	44.5	.4
	Total (A) S.E.	92	61.0 (.4)	59.8 (.4)	-1.2† (.6)	Total (B) S.E.	71	52.3 (.4)	52.2 (.4)	-.1† (.6)
Age 13	1969, 1972 & 1976 (AB) S.E.	23	63.3 (.4)	61.4 (.5)	-1.9 (.6)	1969, 1972 & 1976 (AB) S.E.	23	61.4 (.5)	59.7 (.5)	-1.7 (.7)
	1969 & 1972 (A-AB)	44	58.6	57.0	-1.6	1972 & 1976 (B-AB)	52	51.4	51.2	-.2
	Total (A) S.E.	67	60.2 (.4)	58.5 (.5)	-1.7† (.6)	Total (B) S.E.	75	54.5 (.4)	53.8 (.4)	-.7† (.6)
Age 17	1969, 1973 & 1977 (AB) S.E.	23	44.6 (.4)	42.3 (.4)	-2.3 (.6)	1969, 1973 & 1977 (AB) S.E.	23	42.3 (.4)	39.9 (.4)	-2.4 (.6)
	1969 & 1973 (A-AB)	41	45.6	42.5	-3.0	1973 & 1977 (B-AB)	47	51.4	49.7	-1.7
	Total (A) S.E.	64	45.2 (.3)	42.5 (.3)	-2.8† (.5)	Total (B) S.E.	70	48.4 (.4)	46.5 (.4)	-1.9† (.6)

§ Change statistics were computed prior to rounding to one decimal place.

* Standard errors (S.E.) are not available for the two-assessment exercise sets (A-AB and B-AB).

† Results reported in Chapter 2 of this report.

**TABLE A-2. Group Mean Differences From the National Percentage Correct
for 1970, 1973 and 1977; Change in Mean Differences From 1970 to 1973 and From 1973 to 1977;
and Standard Errors for the Total Change Exercise Sets at Age 9**

	Mean Differences on 92 Exercises			Mean Differences on 71 Exercises		
	1970	1973	Change From 1970-73	1973	1977	Change From 1973-77
Sex						
Male	1.1*	1.0*	-0.1	1.3*	1.3*	0.0
S.E.	(.2)	(.2)	(.2)	(.2)	(.2)	(.2)
Female	-1.1*	-1.0*	0.1	-1.3*	-1.4*	0.0†
S.E.	(.2)	(.1)	(.2)	(.2)	(.2)	(.2)
Race						
White	3.0*	3.0*	0.0	2.7*	2.4*	-0.3
S.E.	(.2)	(.3)	(.4)	(.2)	(.3)	(.4)
Black	-14.2*	-13.6*	0.5	-12.5*	-12.8*	-0.3
S.E.	(.7)	(.6)	(.9)	(.6)	(.7)	(.9)
Region						
Northeast	2.6*	1.8*	-0.8	1.3*	2.1*	0.8
S.E.	(.5)	(.6)	(.8)	(.6)	(.6)	(.9)
Southeast	-5.8*	-4.3*	1.5	-3.8*	-4.2*	-0.4
S.E.	(.7)	(.9)	(1.1)	(.8)	(.9)	(1.1)
Central	1.7*	1.6*	-0.1	1.6*	1.1	-0.5
S.E.	(.6)	(.8)	(1.0)	(.7)	(.8)	(1.1)
West	0.4	0.3	-0.1	0.4	0.4	0.0
S.E.	(.7)	(.8)	(1.0)	(.7)	(.7)	(1.0)
Parental education						
Not graduated high school	-6.9*	-5.2*	1.8*	-5.2*	-6.4*	-1.2
S.E.	(.6)	(.5)	(.8)	(.5)	(.6)	(.8)
Graduated high school	0.5	0.7*	0.2	0.7*	1.1*	0.4
S.E.	(.4)	(.3)	(.5)	(.3)	(.3)	(.4)
Post high school	5.9*	5.4*	-0.5	5.2*	4.5*	-0.7
S.E.	(.3)	(.2)	(.4)	(.3)	(.3)	(.4)
Type of community						
Extreme rural	-3.7*	-2.6*	1.0	-2.2*	0.7	2.9*
S.E.	(1.3)	(1.0)	(1.6)	(.9)	(1.1)	(1.4)
Low metro	-15.2*	-13.4*	1.8	-12.0*	-11.2*	0.8
S.E.	(1.1)	(.8)	(1.4)	(.7)	(1.3)	(1.5)
High metro	8.1*	6.6*	-1.5	5.7*	7.3*	1.6
S.E.	(.7)	(.8)	(1.1)	(.9)	(.8)	(1.2)
Size of community						
Big city	-3.6*	-3.5*	0.1	-3.6*	-4.6*	-1.0
S.E.	(.7)	(.8)	(1.0)	(.7)	(1.0)	(1.2)
Fringes around big cities	4.1*	2.8*	-1.3	2.5*	4.2*	1.7
S.E.	(.7)	(.7)	(1.0)	(.7)	(.6)	(.9)
Medium city	1.2*	1.3	0.2	2.5*	-0.7	-3.2*
S.E.	(.6)	(1.1)	(1.3)	(.9)	(1.4)	(1.6)
Smaller places	-0.1	0.0	0.1	-0.1	0.1	0.2
S.E.	(.4)	(.5)	(.6)	(.5)	(.5)	(.7)

*Denotes differences or changes in differences greater than or equal to two standard errors (S.E.).

†All subtractions were performed prior to rounding to one decimal place.

TABLE A-3. Group Mean Differences From the National Percentage Correct for 1969, 1972 and 1976; Change in Mean Differences From 1969 to 1972 and From 1972 to 1976; and Standard Errors for the Total Change Exercise Sets at Age 13

	Mean Differences on 67 Exercises			Mean Differences on 75 Exercises		
	1969	1972	Change From 1969-72	1972	1976	Change From 1972-76
Sex						
Male	2.0*	2.1*	0.1	1.8*	2.3*	0.5*
S.E.	(.2)	(.2)	(.3)	(.2)	(.2)	(.2)
Female	-1.9*	-2.1*	-0.2	-1.8*	-2.2*	-0.4*
S.E.	(.2)	(.2)	(.3)	(.2)	(.2)	(.2)
Race						
White	3.1*	3.3*	0.3†	2.7*	2.6*	-0.1
S.E.	(.3)	(.3)	(.4)	(.3)	(.3)	(.4)
Black	-15.2*	-16.6*	-1.4	-13.4*	-11.8*	1.6
S.E.	(.5)	(.6)	(.8)	(.5)	(1.0)	(1.1)
Region						
Northeast	2.1*	2.0*	-0.1	1.5*	2.1*	0.6
S.E.	(.6)	(.8)	(1.0)	(.6)	(.7)	(1.0)
Southeast	-4.4*	-3.2*	1.2	-2.7*	-2.7*	0.0
S.E.	(.9)	(.8)	(1.2)	(.7)	(.6)	(.9)
Central	2.2*	1.8*	-0.4	1.5*	1.6*	0.1
S.E.	(.6)	(.8)	(1.0)	(.7)	(.7)	(1.0)
West	-0.2	-0.8	-0.5	-0.4	-1.4*	-1.1
S.E.	(.6)	(.8)	(1.0)	(.7)	(.7)	(1.0)
Parental education						
Not graduated high school	-7.4*	-7.1*	0.4	-5.9*	-6.2*	-0.3
S.E.	(.5)	(.5)	(.7)	(.5)	(.6)	(.7)
Graduated high school	-1.3*	-0.3	1.1*	-0.2	-0.6*	-0.5
S.E.	(.3)	(.3)	(.4)	(.3)	(.3)	(.4)
Post high school	6.0*	6.3*	0.3	5.2*	4.9*	-0.2
S.E.	(.3)	(.3)	(.4)	(.2)	(.2)	(.3)
Type of community						
Extreme rural	-4.3*	-2.0	2.3	-1.9	-0.4	1.6
S.E.	(1.2)	(1.2)	(1.7)	(1.1)	(.9)	(1.4)
Low metro	-11.9*	-13.1*	-1.2	-10.7*	-11.6*	-0.8
S.E.	(1.1)	(1.3)	(1.7)	(1.2)	(1.4)	(1.8)
High metro	6.4*	6.8*	0.4	5.4*	5.6*	0.1
S.E.	(.8)	(.6)	(1.0)	(.6)	(.6)	(.8)
Size of community						
Big city	-3.5*	-3.8*	-0.3	-3.1*	-3.2*	-0.1
S.E.	(.8)	(.9)	(1.2)	(.8)	(1.0)	(1.3)
Fringes around big cities	3.1*	2.0*	-1.1	1.5*	2.5*	1.0
S.E.	(.6)	(.6)	(.9)	(.6)	(1.0)	(1.2)
Medium city	0.8	0.3	-0.5	0.1	-0.1	-0.2
S.E.	(1.0)	(1.2)	(1.6)	(1.1)	(1.0)	(1.5)
Smaller places	0.0	0.1	0.7	0.6	0.2	-0.4
S.E.	(.5)	(.4)	(.7)	(.4)	(.4)	(.6)

*Denotes differences or changes in differences greater than or equal to two standard errors (S.E.).

†All subtractions were performed prior to rounding to one decimal place.

TABLE A-4. Group Mean Differences From the National Percentage Correct for 1969, 1973 and 1977: Change in Mean Differences From 1969 to 1973 and From 1973 to 1977; and Standard Errors for the Total Change Exercise Sets at Age 17

	Mean Differences on 64 Exercises			Mean Differences on 70 Exercises		
	1969	1973	Change From 1969-73	1973	1977	Change From 1973-77
Sex						
Male	3.0*	2.8*	-0.2	3.5*	3.2*	-0.3
S.E.	(.2)	(.2)	(.3)	(.4)	(.4)	(.6)
Female	-2.9*	-2.7*	0.2	-3.3*	-3.2*	0.2†
S.E.	(.2)	(.2)	(.3)	(.2)	(.2)	(.3)
Race						
White	1.6*	1.9*	0.3	2.2*	2.2*	0.0
S.E.	(.2)	(.2)	(.3)	(.2)	(.2)	(.3)
Black	-11.1*	-10.4*	0.7	-12.6*	-13.5*	-0.9
S.E.	(.7)	(.4)	(.8)	(.5)	(.5)	(.7)
Region						
Northeast	1.9*	1.6*	-0.2	1.0	2.3*	1.3
S.E.	(.6)	(.5)	(.8)	(.6)	(.8)	(1.0)
Southeast	-3.2*	-1.6*	1.6	-2.1*	-2.2*	-0.1
S.E.	(.6)	(.6)	(.9)	(.7)	(.7)	(1.0)
Central	0.3	0.6	0.3	1.0	1.2*	0.2
S.E.	(.5)	(.6)	(.8)	(.6)	(.6)	(.9)
West	0.2	-1.1*	-1.3	-0.4	-1.0	-0.6
S.E.	(.5)	(.6)	(.8)	(.6)	(.7)	(1.0)
Parental education						
Not graduated high school	-5.7*	-6.3*	-0.6	-6.6*	-6.9*	-0.3
S.E.	(.4)	(.4)	(.6)	(.4)	(.4)	(.6)
Graduated high school	-1.1*	-1.4*	-0.3	-1.7*	-2.0*	-0.3
S.E.	(.3)	(.3)	(.4)	(.3)	(.2)	(.4)
Post high school	4.2*	4.2*	0.0	4.7*	4.6*	-0.2
S.E.	(.2)	(.2)	(.3)	(.2)	(.2)	(.3)
Type of community						
Extreme rural	-2.9*	-1.4*	1.6	-0.8	-0.3	0.5
S.E.	(1.6)	(.8)	(1.3)	(.8)	(.9)	(1.2)
Low metro	-5.1*	-7.3*	-2.3	-8.1*	-10.1*	-2.1
S.E.	(1.1)	(1.1)	(1.5)	(1.0)	(1.3)	(1.6)
High metro	5.9*	4.4*	-1.5	4.7*	4.4*	-0.3
S.E.	(.7)	(.8)	(1.0)	(.8)	(1.3)	(1.5)
Size of community						
Big city	-1.8*	-3.3*	-1.5	-3.6*	-4.4*	-0.8
S.E.	(.8)	(.8)	(1.2)	(1.0)	(1.0)	(1.4)
Fringes around big cities	2.1*	1.3	-0.8	1.1	2.5*	1.4
S.E.	(.7)	(.8)	(1.0)	(.8)	(.7)	(1.1)
Medium city	0.7	-0.1	-0.8	-0.1	0.2	0.3
S.E.	(.8)	(.8)	(1.2)	(.8)	(1.4)	(1.6)
Smaller places	-0.5	0.5	1.0	0.8*	0.4	-0.3
S.E.	(.4)	(.4)	(.6)	(.4)	(.5)	(.6)

*Denotes differences or changes in differences greater than or equal to two standard errors (S.E.).

†All subtractions were performed prior to rounding to one decimal place.

**TABLE A-5. Group Mean Differences From the National Percentage Correct
for 1970, 1973 and 1977; Change in Mean Differences From 1970 to 1973 and From
1973 to 1977; and Standard Errors for 30 Exercises
Used in All Three Assessments of 9-Year-Olds**

	Mean Differences			Change in Mean Differences	
	1970	1973	1977	1970-73	1973-77
Sex					
Male	1.6*	1.2*	1.7*	-0.4	0.5
S.E.	(.2)	(.2)	(.2)	(.3)	(.3)
Female	-1.7*	-1.2*	-1.7*	0.5	-0.5
S.E.	(.2)	(.2)	(.2)	(.3)	(.3)
Race					
White	2.7*	2.6*	2.3*	0.0†	-0.3
S.E.	(.2)	(.2)	(.3)	(.3)	(.4)
Black	-12.9*	-12.1*	-12.2*	0.8	-0.1
S.E.	(.8)	(.6)	(.9)	(1.1)	(1.1)
Region					
Northeast	2.6*	1.4*	1.9*	-1.2	0.5
S.E.	(.6)	(.6)	(.7)	(.8)	(.9)
Southeast	-5.2*	-3.2*	-4.0*	2.0	-0.8
S.E.	(.9)	(.8)	(.9)	(1.2)	(1.2)
Central	0.9	1.1	0.7	0.2	-0.4
S.E.	(.7)	(.7)	(.9)	(1.0)	(1.2)
West	0.6	0.3	0.9	-0.3	0.6
S.E.	(.7)	(.8)	(.6)	(1.1)	(1.0)
Parental education					
Not graduated high school	-6.7*	-4.7*	-6.2*	2.0*	-1.4
S.E.	(.8)	(.7)	(.9)	(1.0)	(1.1)
Graduated high school	0.7	0.4	0.9*	-0.3	0.5
S.E.	(.5)	(.4)	(.4)	(.6)	(.6)
Post high school	5.2*	4.9*	4.8*	-0.3	-0.1
S.E.	(.4)	(.3)	(.4)	(.5)	(.5)
Type of community					
Extreme rural	-3.1	-1.8	1.9	1.2	3.8*
S.E.	(1.6)	(1.0)	(1.4)	(1.9)	(1.8)
Low metro	-13.7*	-11.7*	-10.9*	2.0	0.9
S.E.	(1.2)	(.9)	(1.5)	(1.5)	(1.8)
High metro	6.3*	5.6*	6.0*	-0.7	0.3
S.E.	(.9)	(1.0)	(.9)	(1.3)	(1.3)
Size of community					
Big city	-4.0*	-3.5*	-4.8*	0.5	-1.3
S.E.	(.7)	(.8)	(1.1)	(1.0)	(1.4)
Fringes around big cities	4.1*	2.3*	4.0*	-1.8	1.7
S.E.	(.7)	(.7)	(.6)	(1.0)	(1.0)
Medium city	1.1	2.5*	-0.9	1.4	-3.3
S.E.	(.8)	(1.2)	(1.6)	(1.4)	(1.9)
Smaller places	0.3	0.0	0.4	-0.2	0.3
S.E.	(.5)	(.5)	(.6)	(.7)	(.8)

*Denotes differences or changes in differences greater than or equal to two standard errors (S.E.).

†All subtractions were performed prior to rounding to one decimal place.

TABLE A-6. Group Mean Differences From the National Percentage Correct for 1969, 1972 and 1976; Changes in Mean Differences From 1969 to 1972 and From 1972 to 1976; and Standard Errors for 23 Exercises Used in All Three Assessments of 13-Year-Olds

	Mean Differences			Changes in Mean Differences	
	1969	1972	1976	1969-72	1972-76
Sex					
Male	1.6*	1.6*	1.5*	0.0	-0.1
S.E.	(.3)	(.2)	(.2)	(.4)	(.3)
Female	-1.5*	-1.6*	-1.5*	0.0†	0.1
S.E.	(.3)	(.2)	(.2)	(.4)	(.3)
Race					
White	2.8*	2.9*	2.6*	0.2	-0.4
S.E.	(.3)	(.3)	(.3)	(.4)	(.5)
Black	-13.6*	-15.2*	-12.1*	-1.6	3.1*
S.E.	(.7)	(.7)	(1.3)	(1.0)	(1.5)
Region					
Northeast	2.0*	2.3*	3.0*	0.3	0.7
S.E.	(.7)	(.8)	(.9)	(1.0)	(1.2)
Southeast	-3.8*	-3.0*	-2.8*	0.9	0.2
S.E.	(.9)	(.8)	(.7)	(1.2)	(1.1)
Central	2.0*	1.2	1.2	-0.8	0.0
S.E.	(.6)	(.8)	(1.0)	(1.0)	(1.3)
West	-0.4	-0.5	-1.9*	-0.1	-1.3
S.E.	(.6)	(.8)	(.8)	(1.0)	(1.2)
Parental education					
Not graduated high school	-7.7*	-6.5*	-6.8*	1.2	-0.3
S.E.	(.6)	(.6)	(.8)	(.9)	(1.0)
Graduated high school	-1.2*	-0.3	-0.5	0.9	-0.2
S.E.	(.4)	(.4)	(.4)	(.5)	(.5)
Post high school	5.5*	5.8*	5.3*	0.2	-0.5
S.E.	(.3)	(.3)	(.2)	(.4)	(.4)
Type of community					
Extreme rural	-4.6*	-2.3	-0.9	2.3	1.4
S.E.	(1.0)	(1.4)	(1.1)	(1.7)	(1.8)
Low metro	-11.4*	-11.8*	-12.8*	-0.5	-1.0
S.E.	(1.2)	(1.4)	(1.9)	(1.9)	(2.4)
High metro	5.5*	6.2*	5.6*	0.8	-0.6
S.E.	(.8)	(.8)	(1.0)	(1.2)	(1.3)
Size of community					
Big city	-2.9*	-3.5*	-3.3*	-0.6	0.2
S.E.	(.9)	(1.1)	(1.2)	(1.4)	(1.6)
Fringes around big cities	2.6*	1.5	2.6*	-1.1	1.1
S.E.	(.7)	(.9)	(1.3)	(1.1)	(1.6)
Medium city	0.8	0.4	0.2	-0.4	-0.2
S.E.	(1.0)	(1.5)	(1.1)	(1.8)	(1.8)
Smaller places	-0.2	0.5	0.1	0.8	-0.4
S.E.	(.5)	(.5)	(.6)	(.7)	(.8)

*Denotes differences or changes in differences greater than or equal to two standard errors (S.E.).

†All subtractions were performed prior to rounding to one decimal place.

**TABLE A-7. Group Mean Differences From the National Percentage Correct
for 1969, 1973 and 1977; Changes in Mean Differences From 1969 to 1973 and From
1973 to 1977; and Standard Errors for 23 Exercises
Used in All Three Assessments of 17-Year-Olds**

	Mean Differences			Change in Mean Differences	
	1969	1973	1977	1969-73	1973-77
Sex					
Male	3.0*	3.2*	2.9*	0.2	-0.3
S.E.	(.3)	(.2)	(.2)	(.4)	(.4)
Female	-2.8*	-3.0*	-2.9*	-0.2	0.2†
S.E.	(.3)	(.2)	(.2)	(.4)	(.4)
Race					
White	1.5*	1.9*	1.8*	0.4	-0.1
S.E.	(.2)	(.2)	(.2)	(.3)	(.3)
Black	-10.4*	-10.6*	-10.9*	-0.1	-0.3
S.E.	(.8)	(.6)	(.6)	(1.0)	(.9)
Region					
Northeast	1.8*	1.4*	2.8*	-0.4	1.4
S.E.	(.7)	(.6)	(.7)	(.9)	(.9)
Southeast	-3.4*	-1.3	-1.8*	2.1*	-0.5
S.E.	(.7)	(.8)	(.7)	(1.0)	(1.0)
Central	0.3	0.3	0.6	0.1	0.3
S.E.	(.7)	(.8)	(.7)	(1.1)	(1.0)
West	0.6	-0.9	-1.2	-1.4	-0.3
S.E.	(.6)	(.7)	(.8)	(1.0)	(1.0)
Parental education					
Not graduated high school	-5.0*	-6.5*	-5.7*	-1.4	0.8
S.E.	(.5)	(.6)	(.6)	(.8)	(.9)
Graduated high school	-1.2*	-1.5*	-1.9*	-0.3	-0.4
S.E.	(.4)	(.4)	(.3)	(.5)	(.5)
Post high school	4.1*	4.3*	3.9*	0.2	-0.4
S.E.	(.3)	(.3)	(.3)	(.4)	(.4)
Type of community					
Extreme rural	-2.5*	-2.0	-0.7	0.5	1.3
S.E.	(1.1)	(1.6)	(.9)	(1.9)	(1.8)
Low metro	-5.1*	-7.4*	-8.8*	-2.3	-1.4
S.E.	(1.0)	(1.0)	(1.0)	(1.4)	(1.4)
High metro	6.5*	5.0*	5.8*	-1.5	0.8
S.E.	(.9)	(1.0)	(1.5)	(1.3)	(1.8)
Size of community					
Big city	-1.4	-4.0*	-3.4*	-2.6*	0.6
S.E.	(.9)	(.9)	(.9)	(1.2)	(1.3)
Fringes around big cities	2.1*	1.6*	2.8*	-0.5	1.2
S.E.	(.7)	(.8)	(.7)	(1.1)	(1.1)
Medium city	0.2	-0.2	0.2	-0.5	0.5
S.E.	(1.1)	(1.1)	(1.0)	(1.6)	(1.5)
Smaller places	-0.5	0.7	-0.1	1.2	-0.8
S.E.	(.5)	(.4)	(.4)	(.7)	(.6)

*Denotes differences or changes in differences greater than or equal to two standard errors (S.E.).

†All subtractions were performed prior to rounding to one decimal place.

APPENDIX B

ESTIMATED POPULATION PROPORTIONS FOR NATIONAL ASSESSMENT REPORTING GROUPS, SAMPLE SIZES AND NUMBER OF EXERCISES USED IN CHANGE SUMMARIES

Table B-1 shows the estimated proportions of the in-school population for reporting groups in 1969-70, 1972-73 and 1976-77. Proportions were estimated separately from

each of the eight assessments conducted between 1969 and 1977. They were then smoothed to dampen sampling fluctuations in order to more properly reflect trends across

TABLE B-1. Estimated Population Proportions of National Assessment Reporting Groups for Ages 9, 13, and 17 in 1969-70, 1972-73 and 1976-77

Reporting Groups	1969-70			1972-73			1976-77		
	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17	Age 9	Age 13	Age 17
Sex									
Male	.495	.498	.489	.499	.500	.492	.502	.497	.490
Female	.505	.502	.511	.501	.500	.508	.498	.503	.510
Race									
White	.843	.851	.876	.808	.824	.853	.812	.808	.836
Black	.133	.132	.109	.141	.128	.112	.128	.135	.116
Other	.024	.017	.015	.051	.048	.035	.060	.057	.048
Region									
Northeast	.251	.245	.244	.260	.249	.268	.252	.257	.249
Southeast	.213	.223	.196	.224	.225	.198	.225	.224	.199
Central	.295	.291	.303	.275	.284	.292	.273	.273	.308
West	.241	.241	.258	.241	.242	.242	.250	.246	.243
Parental education									
Not graduated high school	.103	.154	.210	.095	.148	.173	.090	.134	.151
Graduated high school	.231	.314	.326	.220	.307	.317	.246	.328	.333
Post high school	.341	.412	.416	.325	.406	.463	.323	.408	.469
Unknown	.325	.121	.047	.360	.138	.047	.340	.129	.047
Type of community									
Extreme rural	.086	.096	.088	.085	.095	.081	.092	.102	.081
Low metro	.066	.088	.095	.077	.077	.096	.072	.071	.085
High metro	.124	.118	.140	.126	.118	.121	.102	.110	.102
Other	.724	.698	.677	.712	.710	.702	.734	.716	.732
Size of community									
Big city	.219	.218	.223	.209	.193	.183	.179	.173	.169
Fringes around big cities	.217	.207	.235	.224	.232	.252	.201	.185	.230
Medium city	.135	.144	.142	.139	.142	.143	.146	.132	.146
Smaller places	.428	.431	.399	.428	.433	.422	.474	.510	.455

all eight years.¹ Performance estimates (percentage of correct responses) and estimated population proportions in earlier science reports were based on unsmoothed proportions and may deviate slightly from the figures in this report.

Table B-2 shows total sample sizes by age and assessment year for the summaries in this report. Only 2,100 to 2,600 students responded to any one exercise during any one assessment, and no one student was asked to respond to more than a small fraction of the exercises in each assessment. To compute mean percentages of correct responses, we estimated the percentages of correct responses for each exercise and then averaged the percentages among exercises.

¹The science technical report for the 1976-77 assessment, to be published in 1979, will contain detailed documentation of the smoothing process.

TABLE B-2. Sample Sizes for Science Change Summaries by Age Population and Assessment

Age	1969-70	1972-73	1976-77
9	19,468	20,862*	17,345
13	21,696	23,507	25,653
17	22,913	25,865	29,140

*For 1970-73 summaries, the sample size is 18,638 because one 1973 package had no exercises in common with the 1970 assessment.

Table B-3 shows the number of exercises used to report changes in achievement from 1969-70 to 1972-73 and from 1972-73 to 1976-77. Results are summarized in this report for the total exercise sets and for subsets classified as biology or physical science exercises. Exercises designated "other" are not limited to a specific content area but deal with areas such as the investigative nature of science and processes and methods of science. They have not been summarized separately.

TABLE B-3. Number of Science Change Exercises by Age Population, Assessment Years and Content Classification

Age	Assessments	Biology	Physical Science	Other	Total
9	1970 to 1973	27	50	15	92
	1973 to 1977	24	42	5	71
13	1969 to 1972	23	36	8	67
	1972 to 1976	23	47	5	75
17	1969 to 1973	20	39	5	64
	1973 to 1977	19	45	6	70

The exercise counts in Table B-3 include some exercises that were administered in all three science assessments. Statistics for the common exercises are presented and discussed in Appendix A.

APPENDIX C

PERCENTAGES OF CORRECT RESPONSES AND STANDARD ERRORS FOR SAMPLE EXERCISES IN CHAPTERS 1 AND 2

TABLE C-1. Percentages of Correct Responses and Standard Errors
for Sample Exercises in Chapters 1 and 2*

Reference Number	Description	Age	Mean Percentage Correct		
			1969-70	1972-73	1976-77
101062	Freezing cracks rocks	9	%	51.9	49.4
			S.E.†	(1.3)	(1.5)
		13	%	78.8	71.9
101080	Iron nail rusts easily	9	%	92.2	90.6
			S.E.	(0.8)	(1.1)
		13	%	65.1	58.0
101082	The sun is the largest body	9	%	65.1	58.0
			S.E.	(1.8)	(1.8)
		13	%	80.9	77.8
204038	Graph of beetle move- ment	9	%	(1.4)	(1.5)
			S.E.	35.2	38.0
		13	%	(1.4)	(1.2)
101088	Caterpillar grows to butterfly	9	%	91.3	85.2
			S.E.	(0.8)	(1.2)
		13	%	72.2	63.9
202095	Air pressure collapses can	13	%	(2.0)	(1.6)
			S.E.	28.4	24.8
		17	%	(1.2)	(1.2)
201074	50 percent relative humidity	13	%	47.2	49.0
			S.E.	(1.9)	(1.6)
		17	%	92.5	90.5
204098	Temperature graph	13	%	(1.0)	(1.2)
			S.E.	67.5	63.4
		17	%	(1.4)	(1.4)
102025	Combustion reaction	17	%	21.2	21.5
			S.E.	(1.2)	(1.4)
		17	%	35.6	26.8
201073	Balloon on the moon	13	%	(1.4)	(1.3)
			S.E.	28.7	23.6
		17	%	(1.3)	(1.2)
102024	Minerals with large crystals	17	%	28.7	23.6
			S.E.	(1.3)	(1.2)
					(0.9)

*Exercises are listed in the order of presentation in Chapters 1 and 2.

†Standard error.

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